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GATE 2017

Electrical Engineering

(Afternoon Session : 11-02-2017)

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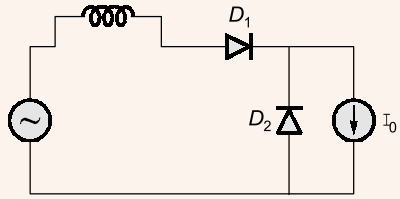
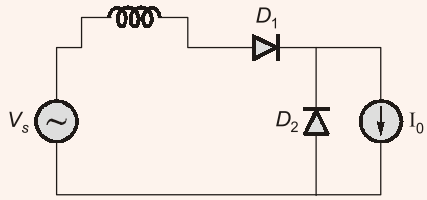
ELECTRICAL ENGINEERING

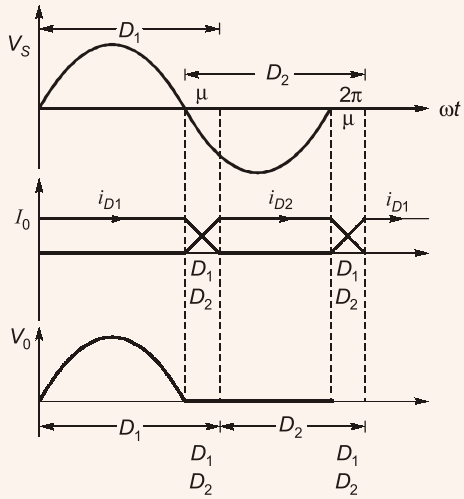
Q.1 In the circuit shown, the diodes are ideal, the inductance is small, and $I_0 \neq 0$. Which one of the following statements is true ?



(a) D_1 conducts for greater than 180° and D_2 conducts for greater than 180°.
(b) D_2 conducts for more than 180° and D_1 conducts for 180°.
(c) D_1 conducts for 180° and D_2 conducts for 180°.
(d) D_1 conducts for more than 180° and D_2 conducts for 180°.

Ans. (a)





Both diodes will conduct for more than 180°.

End of Solution

Q.2 Two resistors with nominal resistance values R_1 and R_2 have additive uncertainties ΔR_1 and ΔR_2 respectively. When these resistances are connected in parallel, the standard deviation of the error in the equivalent resistance R is

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(a) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_1}\Delta R_1\right\}^2+\left\{\frac{\partial R}{\partial R_2}\Delta R_2\right\}^2}$ (b) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_2}\Delta R_1\right\}^2+\left\{\frac{\partial R}{\partial R_1}\Delta R_2\right\}^2}$

(c) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_1}\right\}^2\Delta R_2+\left\{\frac{\partial R}{\partial R_2}\right\}^2\Delta R_1}$ (d) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_1}\right\}^2\Delta R_1+\left\{\frac{\partial R}{\partial R_2}\right\}^2\Delta R_2}$

Ans. (a)

$$\sigma_{res}=\sqrt{\left(\frac{\partial R}{\partial R_1}\right)^2\sigma_1^2+\left(\frac{\partial R}{\partial R_2}\right)^2\sigma_2^2}$$

$$=\sqrt{\left(\frac{\partial R}{\partial R_1}\right)^2\Delta R_1^2+\left(\frac{\partial R}{\partial R_2}\right)^2\Delta R_2^2}$$

End of Solution

Q.3 Let x and y be integers satisfying the following equations.

$$2x^2 + y^2 = 34$$
$$x + 2y = 11$$

The value of $(x + y)$ is _____.

Ans. (7)

$$x + 2y = 1,$$
$$x = 11 - 2y$$
$$2x^2 + y^2 = 34$$
$$2(11 - 2y)^2 + y^2 = 34$$
$$24^2 + 8y^2 - 88y + y^2 - 34 = 0$$
$$9y^2 - 88y + 208 = 0$$
$$y = 5.77, 4$$
$$x = -0.54,$$
$$x = 11 - 2(4) = 3$$
$$x = 3,\ y = 4$$
$$x + y = 3 + 4 = 7$$

End of Solution

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Q.4 In a load flow problem solved by Newton-Raphson method with polar coordinates, the size of the Jacobian is 100 × 100. If there are 20 PV buses in addition to *PQ* buses and a slack bus, the total number of buses in the system is_____.

Ans. (61)

$$[J] = [2n - m - 2]$$
$$100 = [2n - 20 - 2]$$
$$n = \frac{100 + 22}{2} = 61$$

Total number of buses = n = 61

End of Solution

Q.5 A stationary closed Lissajous pattern on an oscilloscope has 3 horizontal tangencies and 2 vertical tangencies for a horizontal input with, frequency 3 kHz. The frequency of the vertical input is,

(a) 1.5 kHz (b) 2 kHz
(c) 3 kHz (d) 4.5 kHz

Ans. (d)

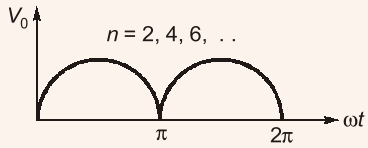
$$\frac{f_y}{f_x} = \frac{\text{Horizontal Tanencies}}{\text{Vertical Tangencies}}$$
$$\Rightarrow \quad \frac{f_y}{3} = \frac{3}{2}$$
$$\Rightarrow \quad f_y = 4.5 \text{ kHz}$$

End of Solution

Q.6 A phase-controlled, single-phase, full-bridge converter is supplying a highly inductive DC load. The converter is fed from a 230 V, 50 Hz, AC source. The fundamental frequency in Hz of the voltage ripple on the DC side is

(a) 25 (b) 50
(c) 100 (d) 300

Ans. (c)



All even harmonics are present.
Fundamental frequency=$2f_s$ = 2 × 50 = 100 Hz

End of Solution

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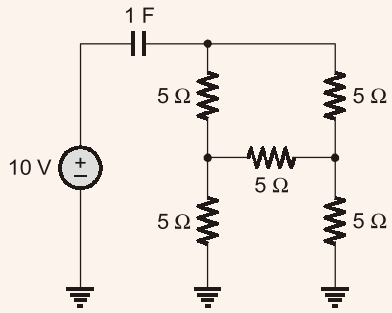
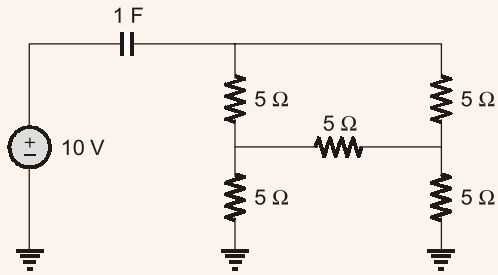
Q.7 The initial charge in the 1 F capacitor present in the circuit shown is zero. The energy in joules transferred from the DC source until steady state condition is reached equals _____. (Give the answer upto one decimal place.)

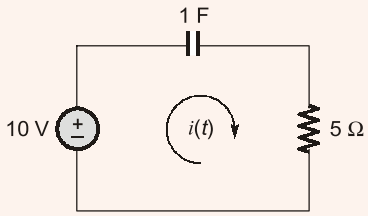


Ans. (100)

Consider the following circuit diagram,



After minimizing circuit elements we can have the following circuit,



Here, $\tau = RC = 5$ sec.

Now current, $i(t) = \frac{V}{R}e^{-t/\tau} = \frac{10}{3}e^{-t/5} = 2e^{-0.2t}$

Energy supplied by the source,

$$E = \int_0^\infty 10 \times 2e^{-0.2t}\, dt = 100 \text{ J}$$

End of Solution

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Q.8 The transfer function $C(s)$ of a compensator is given below.

$$C(s) = \frac{\left(1+\frac{s}{0.1}\right)\left(1+\frac{s}{100}\right)}{(1+s)\left(1+\frac{s}{10}\right)}$$

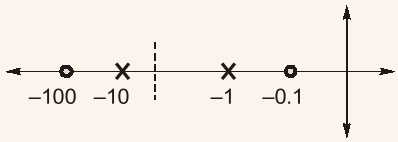
The frequency range in which the phase (lead) introduced by the compensator reaches the maximum is

(a) $0.1 < \omega < 1$ (b) $1 < \omega < 10$

(c) $10 < \omega < 100$ (d) $\omega > 100$

Ans. (a)

Pole zero diagram of compensator transfer function is shown below.

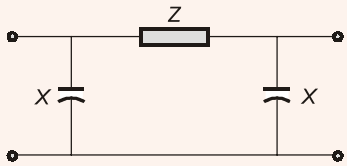


Maximum phase lead is between 0.1 and 1.

$$0.1 < \omega < 1$$

End of Solution

Q.9 The nominal-π circuit of a transmission line is shown in the figure.

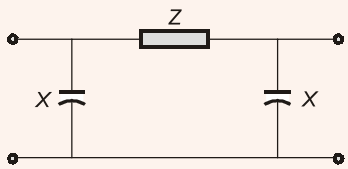


Impedance $Z = 100\angle 80^\circ\ \Omega$ and reactance $X = 3300\ \Omega$. The magnitude of the characteristic impedance of the transmission line, in Ω, is_____.(Give the answer up to one decimal place.)

Ans. (406.2)

$$Z = 100\angle 80^\circ$$

$$X = 3300\ \Omega$$



$$\frac{y}{2} = \frac{1}{X} \Rightarrow \frac{1}{3300}$$

$$y = \frac{2}{3300} = 6.06\times 10^{-4}$$

$$Z_C = \sqrt{\frac{Z}{y}} = \sqrt{\frac{100}{6.06\times 10^{-4}}} = 406.2\ \Omega$$

End of Solution

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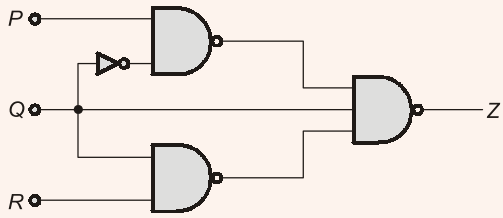
Q.10 Assume that in a traffic junction, the cycle of the traffic signal lights is 2 minutes of green (vehicle does not stop) and 3 minutes of red (vehicle stops). Consider that the arrival time of vehicles at the junction is uniformly distributed over 5 minute cycle. The expected waiting time (in minutes) for the vehicle at the junction is_____.

Ans. (*)

End of Solution

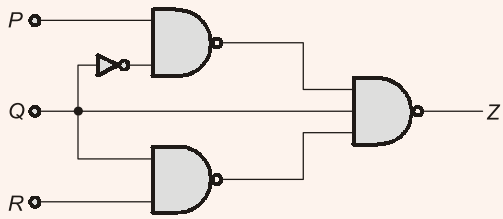
Q.11 For a 3-input logic circuit shown below, the output Z can be expressed as



(a) $Q+\bar{R}$ (b) $P\bar{Q}+R$

(c) $\bar{Q}+R$ (d) $P+\bar{Q}+R$

Ans. (c)



$$Z=\overline{P\bar{Q}\cdot Q\cdot\overline{Q\cdot R}}=\overline{P\bar{Q}}+\bar{Q}+\overline{\overline{Q\cdot R}}$$

$$=P\bar{Q}+\bar{Q}+QR=\bar{Q}(P+1)+QR$$

$$=\bar{Q}+QR=(\bar{Q}+Q)\cdot(\bar{Q}+R)=\bar{Q}+R$$

End of Solution

Q.12 Consider a solid sphere of radius 5 cm made of a perfect electric conductor. If one million electrons are added to this sphere, these electrons will be distributed

(a) uniformly over the entire volume of the sphere

(b) uniformly over the outer surface of the sphere

(c) concentrated around the centre of the sphere

(d) along a straight line passing through the centre of the sphere

Ans. (b)

Added charge (one million electrons) to be solid spherical conductor is uniformly distributed over the outer surface of the sphere.

End of Solution

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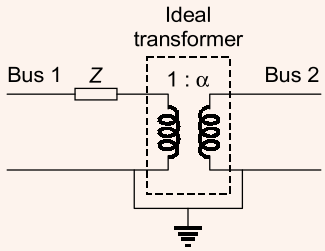
Q.13 The figure shows the per-phase representation of a phase-shifting transformer connected between buses 1 and 2, where α is a complex number with non-zero real and imaginary parts.



For the given circuit Y_{BUS} and Z_{BUS} are bus admittance matrix and bus impedance matrix, respectively, each of size 2 × 2. Which one of the following statements is true?

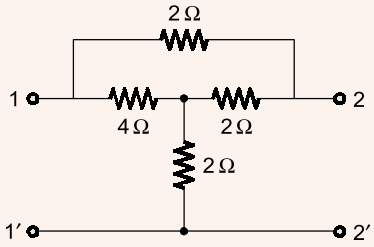
(a) Both Y_{BUS} and Z_{BUS} are symmetric.
(b) Y_{BUS} is symmetric and Z_{BUS} is unsymmetric.
(c) Y_{BUS} is unsymmetric and Z_{BUS} is symmetric.
(d) Both Y_{BUS} and Z_{BUS} are unsymmetric.

Ans. (d)

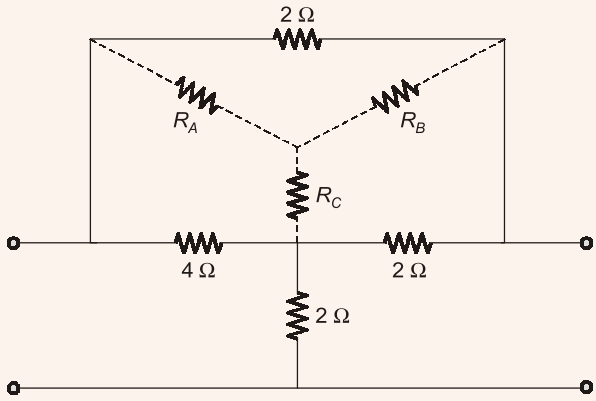
Both Y_{BUS} and Z_{BUS} are unsymmetrical with transformer.

End of Solution

Q.14 For the given 2-port network, the value of transfer impedance Z_{21} in ohms is _____.



Ans. (3)



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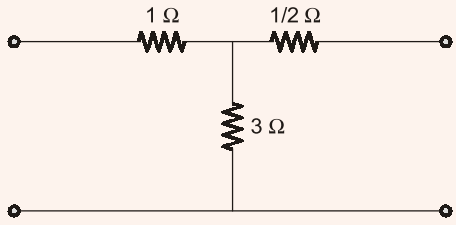
where, $R_A = 1\ \Omega$
$R_B = 1\ \Omega$
$R_C = 1/2\ \Omega$

After rearrangement consider the following circuit,



From the circuit diagram we get,

$$Z_{21} = \frac{V_2}{I_1} = 3\ \Omega$$

End of Solution

Q.15 Consider a function $f(x, y, z)$ given by

$$f(x, y, z) = (x^2 + y^2 - 2z^2)(y^2 + z^2)$$

The partial derivative of this function with respect to x at the point, $x = 2$, $y = 1$ and $z = 3$ is _____.

Ans. (40)

$$f(x, y, z) = (x^2 + y^2 - 2z^2)(y^2 + z^2)$$

$$\frac{\partial f}{\partial x} = (x^2 + y^2 - 2z^2)(0) + (y^2 + z^2)(2x)$$

$$= 0 + (y^2 + z^2)(2x)$$

$$\left.\frac{\partial f}{\partial x}\right|_{\substack{x=2\\y=1\\z=3}} = (1 + 9)2\ (2) = 40$$

End of Solution

Q.16 When a unit ramp input is applied to the unity feedback system having closed loop transfer function; $\frac{C(s)}{R(s)} = \frac{Ks+b}{s^2+as+b}, (a>0,\ b>0,\ K>0)$, the steady state error will be,

(a) 0

(b) $\frac{a}{b}$

(c) $\frac{a+K}{b}$

(d) $\frac{a-K}{b}$

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Ans. (d)

Close loop transfer function = $\dfrac{Ks+b}{s^2+as+b}$

Open loop transfer function = $G(s)=\dfrac{Ks+b}{s^2+as+b-Ks-b}$

$$G(s)=\frac{Ks+b}{s^2+as-Ks}=\frac{Ks+b}{s(s+a-K)}$$

Steady state error for ramp input given to type-1 system = $\dfrac{1}{K_V}$

where, velocity error coefficient,

$$K_V=\lim_{s\to 0} s\cdot\frac{Ks+b}{s(s+a-K)}=\frac{b}{a-K}$$

Steady state error, $e_{ss}=\dfrac{a-K}{b}$

End of Solution

Q.17 If a synchronous motor is running at a leading power factor, its excitation induced voltage (E_f) is

(a) equal to terminal voltage V_t
(b) higher than the terminal voltage V_t
(c) less than terminal voltage V_t
(d) dependent upon supply voltage V_t

Ans. (b)

Synchronous motor-leading p.f. over excited.

$\therefore$ $E_f > V$

End of Solution

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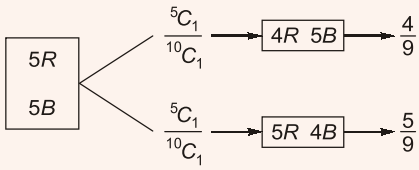
Q.18 An urn contains 5 red balls and 5 black balls. In the first draw, one ball is picked at random and discarded without noticing its colour. The probability to get a red ball in the second draw is

(a) $\frac{1}{2}$ (b) $\frac{4}{9}$

(c) $\frac{5}{9}$ (d) $\frac{6}{9}$

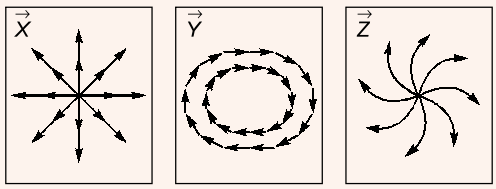
Ans. (0.5)



$$P(\text{red}) = \frac{5}{10}\cdot\frac{4}{9}+\frac{5}{10}\cdot\frac{5}{9}=\frac{45}{90}=0.5$$

End of Solution

Q.19 The figures show diagramatic representations of vector fields X, Y and Z, respectively. Which one of the following choices is true?



(a) $\nabla\cdot X=0, \nabla\times Y\neq 0, \nabla\times Z=0$ (b) $\nabla\cdot X\neq 0, \nabla\times Y=0, \nabla\times Z\neq 0$

(c) $\nabla\cdot X\neq 0, \nabla\times Y\neq 0, \nabla\times Z\neq 0$ (d) $\nabla\cdot X=0, \nabla\times Y=0, \nabla\times Z=0$

Ans. (c)

X is going away so $\nabla\cdot X\neq 0$.

Y is moving circulator direction so $\nabla\times Y\neq 0$.

Z has circular rotation so $\nabla\times Z\neq 0$.

End of Solution

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Q.20 A 3-phase, 4-pole, 400 V, 50 Hz squirrel-cage induction motor is operating at a slip of 0.02. The speed of the rotor flux in mechanical rad/sec, sensed by a stationary observer, is closest to

(a) 1500 (b) 1470

(c) 157 (d) 154

Ans. (c)

$$N_s = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

$$s = 0.02$$

$$N = N_s(1 - s)$$

$$= 1500(1 - 0.02) = 1470 \text{ rpm}$$

As it was specified rotor rmf with respect to stationary part/stator.

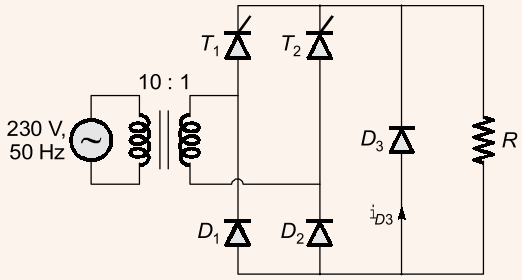
Rotor rmf w.r.t. stator is always @ N_s.

$\therefore$ Speed of rotor flux in mechanical radian/sec.

$$= \frac{2 \times 3.14 \times 1500}{60} = 157 \text{ rad/sec.}$$

End of Solution

Q.21 The figure below shows the circuit diagram of a controlled rectifier supplied from a 230 V, 50 Hz, 1-phase voltage source and a 10:1 ideal transformer. Assume that all devices are ideal. The firing angles of the thyristors T_1 and T_2 are 90° and 270°, respectively.



The RMS value of the current through diode D_3 in amperes is _____.

Ans. (0)

FD will not conduct for resistive load.

End of Solution

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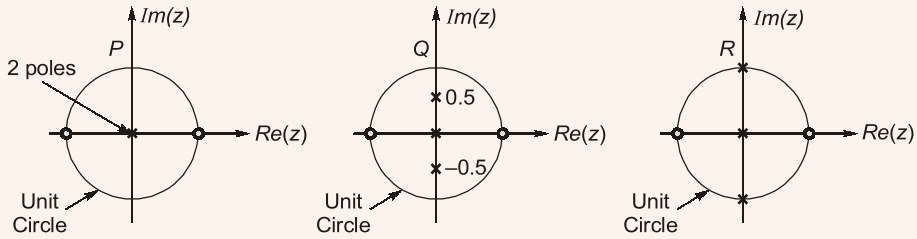
Q.22 The pole-zero plots of three discrete-time systems P, Q and R on the z-plane are shown below.



Which one of the following is TRUE about the frequency selectivity of these systems?

(a) All three are high-pass filters.

(b) All three are band-pass filters.

(c) All three are low-pass filters.

(d) P is a low-pass filter, Q is a band-pass filter and R is a high-pass filter.

Ans. (b)

For figure 1:

$$H(z) = \frac{K(z^2 - 1)}{z^2}$$

At low frequency, i.e. $z = 1$

$$|H(1)| = 0$$

At high frequency, i.e. $z = -1$

$$|H(-1)| = 0$$

Hence filter type is BPF.

For figure 2:

$$H(z) = \frac{K(z^2 - 1)}{z^2 + 0.25}$$

At low frequency, i.e. $z = 1$

$$|H(1)| = 0$$

At high frequency, i.e. $z = -1$

$$|H(-1)| = 0$$

Hence filter type is BPF.

For figure 3:

$$H(z) = \frac{z^2 - 1}{z^2 + 1}$$

At low frequency, i.e. $z = 1$

$$|H(1)| = 0$$

At high frequency, i.e. $z = -1$

$$|H(-1)| = 0$$

Hence filter type is BPF.

End of Solution

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Q.23 Let $y^2 - 2y + 1 = x$ and $\sqrt{x} + y = 5$. The value of $x + \sqrt{y}$ equals_____.
(Give the answer up to three decimal places).

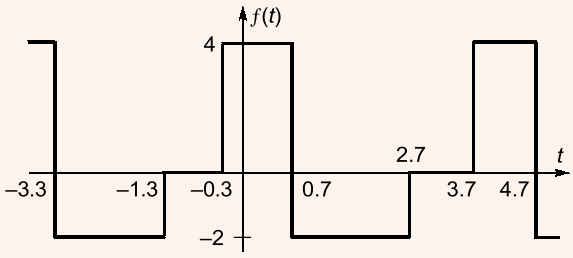
Ans. (5.732)

$$y^2 - 2y + 1 = x$$
$$(y-1)^2 = x$$
$$y - 1 = \sqrt{x}$$
$$y = 1 + \sqrt{x}$$
$$y = 1 + \sqrt{4} = 3$$
$$\therefore \quad = 3$$
$$x + \sqrt{y} = 4 + \sqrt{3} = 5.732$$

$$\sqrt{x} + y = 5$$
$$\sqrt{x} + 1 + 5x = 5$$
$$2\sqrt{x} = 4$$
$$\sqrt{x} = 2$$
$$x = 4$$

End of Solution

Q.24 The mean square value of the given periodic waveform $f(t)$ is _____.



Ans. (6)

Mean square value = Power of $f(t)$

$$\text{Mean square value} = \frac{1}{T_0}\int_{T_0} |f(t)|^2\, dt$$
$$= \frac{1}{4}[4^2 \times 1 + 2^2 \times 2]$$
$$= \frac{16+8}{4} = \frac{24}{4} = 6$$

End of Solution

Q.25 A three-phase voltage source inverter with ideal devices operating in 180° conduction mode is feeding a balanced star-connected resistive load. The DC voltage input is V_{dc}. The peak of the fundamental component of the phase voltage is

(a) $\frac{V_{dc}}{\pi}$ (b) $\frac{2V_{dc}}{\pi}$

(c) $\frac{3V_{dc}}{\pi}$ (d) $\frac{4V_{dc}}{\pi}$

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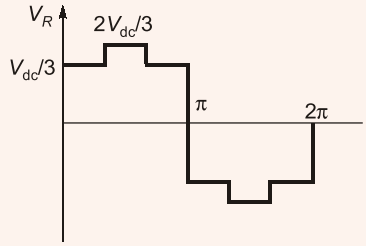
Ans. (b)

3-ϕ VSI 180° mode



$$V_{Rn} = \frac{6.V_{dc}/3}{n\pi}\sin n\omega t = \frac{2\times V_{dc}}{n\pi}\sin n\omega t$$

$$V_{R1} = \frac{2V_{dc}}{\pi}\sin\omega t$$

End of Solution

Q.26 A $10\frac{1}{2}$ digit timer counter possesses a base clock of frequency 100 MHz. When measuring a particular input, the reading obtained is the same in:

(i) Frequency mode of operation with a gating time of one second and

(ii) Period mode of operation (in the × 10 ns scale). The frequency of the unknown input (reading obtained) in Hz is_____.

Ans. (100000000)

1. $10\frac{1}{2}$ digital timer counter:

   Frequency mode of operation: $f = \frac{n}{t}$

   Let $f \Rightarrow$ freqeuncy of input signal

   Let $n \Rightarrow$ number of cycles of repetitive signal $\Rightarrow 100 \times 10^6$

   Let $t \Rightarrow$ Gate time $\Rightarrow t = 1$ sec

   $$f = \frac{100\times10^6}{1\,\text{sec}} = 10^8\ \text{Hz} = 10^8\text{cycles/sec.}$$

   On $10\frac{1}{2}$ digit display $\Rightarrow$ 1 0 0 0 0 0 0 0 0 • 0 0 Hz

2. Period mode of operation:

   $$P = \frac{1}{f} = \frac{t}{n} = \frac{1\,\text{sec}}{100\times10^6}$$

   Let, $P \Rightarrow$ Period of input signal

   $$P = 0.01 \times 10^{-6} = 1 \times 10^{-8}$$
   $$= 10 \times 10^{-9} = 1 \times 10 \times 10^{-9} = 1 \times 10\ \text{n-sec.}$$
   $$= 1\ 0 \bullet 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ \text{n-sec}$$

End of Solution

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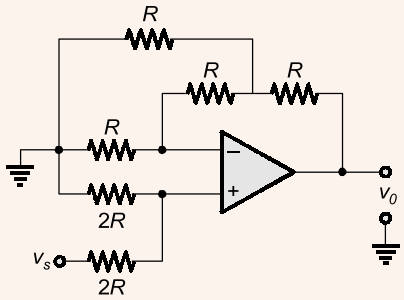
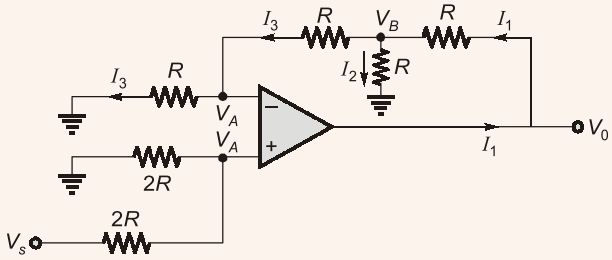
Q.27 For the circuit shown below, assume that the OPAMP is ideal. Which one of the following is TRUE ?



(a) $v_0 = v_s$
(b) $v_0 = 1.5\ v_s$
(c) $v_0 = 2.5\ v_s$
(d) $v_0 = 5\ v_s$

Ans. (c)



$$V_A = \frac{V_s}{2}$$

$$I_3 = \frac{V_A}{R} = \frac{V_s}{2R} \qquad \text{...(i)}$$

$$V_B - V_A = I_3 R$$

$$V_B = V_A + I_3 R = \frac{V_s}{2} + \frac{V_s}{2} = V_s$$

$$I_2 = \frac{V_B}{R} = \frac{V_s}{R} \qquad \text{...(ii)}$$

$$I_1 = I_2 + I_3$$

$$= \frac{V_s}{R} + \frac{V_s}{2R} = \frac{V_s}{R}[1.5]$$

$$V_0 - V_B = I_1 R$$

$$\Rightarrow \quad V_0 = V_B + \frac{V_s}{R}[1.5]\,R = V_s + 1.5V_s = 2.5\ V_s$$

End of Solution

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AIR-1	AIR-2	AIR-3	AIR-4	AIR-5	AIR-6	AIR-7	AIR-8	AIR-9	AIR-10
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ME — 9 Selections in Top 10

AIR-1	AIR-3	AIR-4	AIR-5	AIR-6	AIR-7	AIR-8	AIR-9	AIR-10
Mohd Idul Ahmad	Chirag Srivastav	Taronjot Singh	Deepak Vijay	Dheeraj Kumar	Tarun Kumar	JGMV Pramod	Gaurav Kant	Jivitesh Anand

EE — 10 Selections in Top 10

AIR-1	AIR-2	AIR-3	AIR-4	AIR-5	AIR-6	AIR-7	AIR-8	AIR-9	AIR-10
Gaurav	B Venkatesh	Tanuj K Sharma	Varsha	Ashish Verma	Mufeed Khan	Shyamji D.	Sk Taushifur R.	Arvind Biswal	Gaurav Tyagi

E&T — 10 Selections in Top 10

AIR-1	AIR-2	AIR-3	AIR-4	AIR-5	AIR-6	AIR-7	AIR-8	AIR-9	AIR-10
Naveen B. Sharma	Amit Rawat	Aswathy S.	Thaduri Naveen	Vinit Ranjan	Harshit Jain	Akash Chhikara	Vivek Jain	Jadugurla N.	Prabhakar

39 Selections in Top 10 | **76** Selections in Top 20 | **505** Selections out of total 604 vacancies

CE	Selections in Top 10 **10**	MADE EASY Selections **182** Out of **225** Vacancies	MADE EASY Percentage **81%**
ME	Selections in Top 10 **9**	MADE EASY Selections **159** Out of **179** Vacancies	MADE EASY Percentage **89%**
EE	Selections in Top 10 **10**	MADE EASY Selections **86** Out of **106** Vacancies	MADE EASY Percentage **81%**
E&T	Selections in Top 10 **10**	MADE EASY Selections **78** Out of **94** Vacancies	MADE EASY Percentage **83%**

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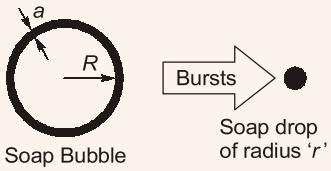
Q.28 A thin soap bubble of radius R = 1 cm, and thickness a = 3.3 μm ($a << R$), is at a potential of 1 V with respect to a reference point at infinity, The bubble bursts and becomes a single spherical drop of soap (assuming all the soap is contained in the drop) of radius r. The volume of the soap in the thin bubble is $4\pi R^2 a$ and that of the drop is $\frac{4}{3}\pi r^3$. The potential in volts, of the resulting single spherical drop with respect to the same reference point at infinity is _____.
(Give the answer up to two decimal places.)



Ans. (10.03)

After burst, $4\pi R^2 a = \frac{4}{3}\pi r^3$

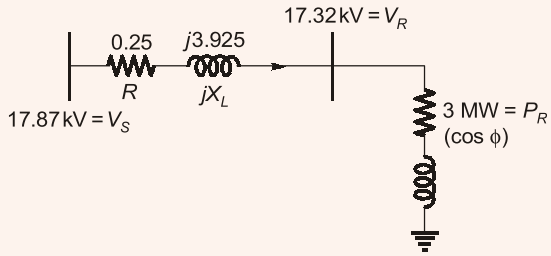
$\Rightarrow$ Radius of soap drop = $(3R^2 a)^{1/3}$ = 0.099 cm
Initial voltage was 1 V and $C = 4\pi\varepsilon_0 R$
and initial charge, $Q = (4\pi\varepsilon_0 R \times 1)$
since after bursting Q remain same and $C = 4\pi\varepsilon_0 r$
$\Rightarrow$ New potential on soap drop,

$$V = \frac{Q}{C} = \frac{4\pi\varepsilon_0 R}{4\pi\varepsilon_0 r} = \frac{1}{0.099} = 10.03 \text{ V}$$

End of Solution

Q.29 A 3-phase, 50 Hz generator supplies power of 3 MW at 17.32 kV to a balanced 3-phase inductive load through an overhead line. The per phase line resistance and reactance are 0.25 Ω and 3.925 Ω respectively. If the voltage at the generator terminal is 17.87 kV, the power factor of the load is _____.

Ans. (0.8)



$$V_S - V_R = I(R\cos\phi + X_L \sin\phi)$$

$$I = \frac{P_R}{V_R \cos\phi}$$

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$$V_S - V_R = \frac{P_R}{V_R \cos\phi}(R\cos\phi + X_L \sin\phi)$$

$$\tan\phi = \left(\frac{V_S V_R - V_R^2 - R P_R}{X_L P_R}\right)$$

$$\phi = \tan^{-1}\left[\frac{V_S V_R - V_R^2 - R P_R}{X_L P_R}\right] \Rightarrow \text{Substitude all values}$$

Power factor = $\cos\phi = 0.8$ lag

End of Solution

Q.30 A 3-phase, 2-pole, 50 Hz, synchronous generator has a rating of 250 MVA, 0.8 pf lagging. The kinetic energy of the machine at synchronous speed is 1000 MJ. The machine is running steadily at synchronous speed and delivering 60 MW power angle at a power of 10 electrical degrees. If the load is suddenly removed, assuming the acceleration is constant for 10 cycles, the value of the power angle after 5 cycles is_____electrical degrees.

Ans. (12.7)

$S = 250$ MVA,

$\cos\phi = 0.8$

K.E. = 1000 MJ

$P_e = 60$ MW

$\delta_0 = 10°$

$$t = 10 \text{ cycles} = \frac{10}{50} = 0.2 \text{ sec}$$

$t = 5$ cycles $\Rightarrow 0.1$ sec

Load is removed, $P_e = 0$

$P_a = P_m - P_e$

$\Rightarrow$ $P_m = 60$ MW,

$$M = \frac{HS}{180f} = \frac{K.E.}{180f} = \frac{1000}{180 \times 50} = 0.111$$

$$\delta = \frac{P_a}{M}.\left(\frac{t_2}{2}\right)$$

$$\Rightarrow \quad \frac{60}{0.11} \times \frac{0.1^2}{2} = 2.7°$$

So, new ratio

$\Rightarrow$ $\delta = 10 + 27° = 12.7°$

End of Solution

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Q.31 Which of the following systems has maximum peak overshoot due to a unit step input ?

(a) $\dfrac{100}{s^2+10s+100}$ (b) $\dfrac{100}{s^2+15s+100}$

(c) $\dfrac{100}{s^2+5s+100}$ (d) $\dfrac{100}{s^2+20s+100}$

Ans. (c)

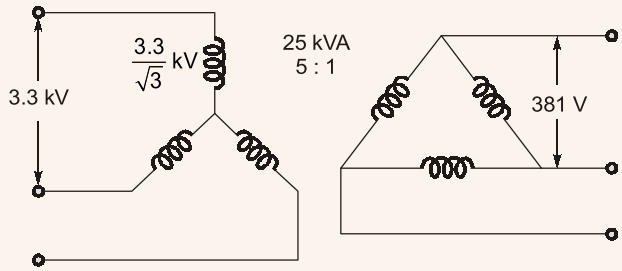
For maximum peak over shoot $M_P \propto \dfrac{1}{\xi}$

ξ = 0.25 for option (c) which is least among all options. Therefore correct option is (c).

End of Solution

Q.32 If the primary line voltage rating is 3.3 kV(Y side) of a 25 kVA, *Y*-Δ transformer (the per phase turns ratio is 5 : 1), then the line current rating of the secondary side (in Ampere) is_____.

Ans. (37.88)



From turn ratio,

$$V_2 = 381 \text{ V/phase}$$

$$V_{2\,\text{line}} = 381 \text{ V}$$

$$\sqrt{3}V_2I_2 = 25000$$

$$\therefore \quad I_2 = \frac{25000}{\sqrt{3}\times 381} = 37.88 \text{ A}$$

End of Solution

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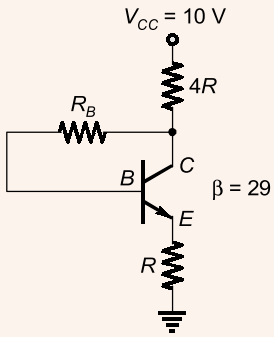
Q.33 For the circuit shown in the figure below, it is given that $V_{CE} = \frac{V_{CC}}{2}$. The transistor has $\beta = 29$ and $V_{BE} = 0.7$ V when the *B*-*E* junction is forward biased.



For this circuit, the value of $\frac{R_B}{R}$ is

(a) 43 (b) 92

(c) 121 (d) 129

Ans. **(d)**

In input loop, $10 = (1 + \beta) I_B \times 4R + I_B \times R_B + 0.7 + (1 + \beta) I_B \times R$

$10 = 30\ I_B \times 4R + I_B \times R_B + 0.7 + 30 \times I_B \times R$

$9.3 = 150 \times I_B \times R + I_B \times R_B$ ...(i)

Output loop, $10 = (1 + \beta) \times I_B \times 4R + 5\ \text{V} + (1 + \beta) \times I_B \times R$

$5 = 30 I_B \times 4R + 30 \times I_B \times R$

$5 = 150 \times I_B \times R$ ...(ii)

Using equation (i) and (ii),

$I_B R_B = 9.3 - 5 = 4.3$

and simultaneously putting value of $I_B R$ from equation (ii) in equation (i),

$$9.3 = I_B R\left[150 + \frac{R_B}{R}\right]$$

$$9.3 = \frac{5}{150}\left[150 + \frac{R_B}{R}\right]$$

$$279 = 150 + \frac{R_B}{R}$$

$$\frac{R_B}{R} = 129$$

End of Solution

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Q.34 The value of the contour integral in the complex-plane

$$\int \frac{z^3 - 2z + 3}{z - 2} dz$$

along the contour $|z| = 3$, taken counter-clockwise is

(a) $-18\pi i$ (b) 0

(c) $14\pi i$ (d) $48\pi i$

Ans. (c)

Pole, $z = 2$ lies inside $|z| = 3$

$$\text{Res } f(z) = \lim_{z \to 2} (z-2) \frac{z^2 - 2z + 3}{z - 2}$$

$z = 2$, $= 8 - 4 + 3 = 7$

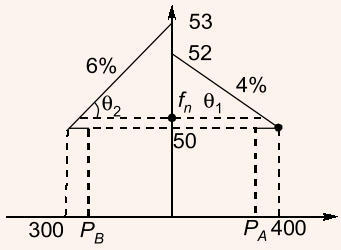
By Cauche residue theorem

$$I = 2\pi i(7) = 14\pi i$$

End of Solution

Q.35 Two generating units rated 300 MW and 400 MW have governor speed regulation of 6% and 4% respectively from no load to full load. Both the generating units are operating in parallel to share a load of 600 MW. Assuming free governor action, the load shared by the larger units is _____MW.

Ans. (333)



$$\tan\theta_1 = \frac{52 - f_x}{P_A} = \frac{52 - 50}{400} = \frac{2}{400} = \frac{1}{200} \quad \ldots \text{(i)}$$

$$\tan\theta_2 = \frac{53 - f_x}{P_B} = \frac{53 - 50}{300}$$

$$\frac{53 - f_x}{600 - P_A} = \frac{3}{300} = \frac{1}{100} \quad \ldots \text{(ii)}$$

By solving (i) and (2)

$f_x = 50.33$ Hz

$P_A = 333$ MW,

$P_B = 267$ MW

Load shared by larger unit = 333 MW

End of Solution

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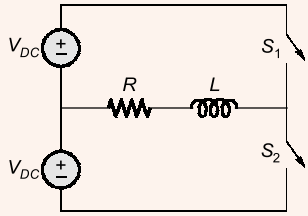
Q.36 The figure below shows a half-bridge voltage source inverter supplying an RL-load with $R = 40\ \Omega$ and $L = \left(\frac{0.3}{\pi}\right) H$. The desired fundamental frequency of the load voltage is 50 Hz. The switch control signals of the converter are generated using sinusoidal pulse width modulation with modulation index, $M = 0.6$. At 50 Hz, the RL-load draws an active power of 1.44 kW. The value of DC source voltage V_{DC} in volts is



(a) $300\sqrt{2}$ (b) 500

(c) $500\sqrt{2}$ (d) $1000\sqrt{2}$

Ans. (d)

$$V_{01peak} = M \cdot \frac{V_{DC}}{2} \qquad M \rightarrow \text{Modulation index}$$

$$V_{01rms} = \frac{M \cdot \frac{V_{DC}}{2}}{\sqrt{2}} = M \cdot \frac{V_{DC}}{2\sqrt{2}}$$

$$V_{01rms} = \frac{0.6\, V_{dc}}{2\sqrt{2}}$$

$$V_{01} = \frac{0.3}{\sqrt{2}} V_{dc}$$

$$|Z_1| = \sqrt{R^2 + (\omega L)^2} = \sqrt{40^2 + (2\pi f \cdot L)^2}$$

$$= \sqrt{40^2 + \left(2\pi \times 50 \times \frac{0.3}{\pi}\right)^2} = \sqrt{40^2 + 30^2} = 50$$

$$\phi_1 = \tan^{-1}\frac{\omega L}{R} = \tan^{-1}\frac{30}{40} = 39.869°$$

$$\phi_1 = 39.869$$

$$\text{Active power} = V_{01}\, I_{01} \cos\phi_1 = V_{01} \cdot \frac{V_{01}}{|Z_1|} \cdot \cos\phi_1$$

$$1.44 \times 10^3 = \left(\frac{0.3}{\sqrt{2}} V_{DC}\right)^2 \cdot \frac{1}{50} (\cos 36.869°)$$

$$\therefore \quad V_{DC}^2 = \frac{1.44 \times 10^3 \times 100}{0.3^2 (0.8)} = 20 \times 10^5$$

$$V_{DC} = \sqrt{2} \cdot 10^3 = 1000\sqrt{2}\ V$$

End of Solution

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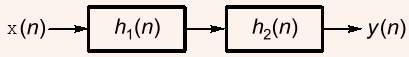
Q.37 A cascade system having the impulse responses $h_1(n) = \{\underset{\uparrow}{1}, -1\}$ and $h_2(n) = \{\underset{\uparrow}{1}, 1\}$ is shown in the figure below, where symbol $\uparrow$ denotes the time origin.



The input sequence $x(n)$ for which the cascade system produces an output sequence $y(n) = \{\underset{\uparrow}{1}, 2, 1, -1, -2, -1\}$ is

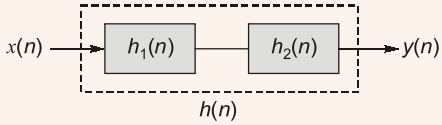
(a) $x(n) = \{\underset{\uparrow}{1}, 2, 1, 1\}$

(b) $x(n) = \{\underset{\uparrow}{1}, 1, 2, 2\}$

(c) $x(n) = \{\underset{\uparrow}{1}, 1, 1, 1\}$

(d) $x(n) = \{\underset{\uparrow}{1}, 2, 2, 1\}$

Ans. (d)



Now, $h(n)$ = overall system impulse response

$= h_1(n) * h_2(n)$

$= \{\underset{\uparrow}{1}, -1\} * \{\underset{\uparrow}{1}, 1\}$

$= \{\underset{\uparrow}{1}, 0, -1\}$ $\quad H(z) = 1 - z^{-2}$

As we know, $H(z) = \dfrac{Y(z)}{X(z)}$

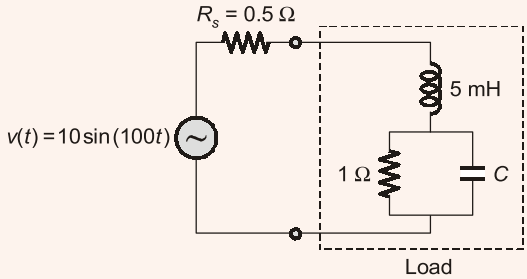
$\Rightarrow$ $X(z) = \dfrac{Y(z)}{X(z)} = \dfrac{1 + 2z^{-1} + z^{-2} - z^{-3} - 2z^{-4} - z^{-5}}{1 - z^{-2}}$

$= 1 + 2z^{-1} + 2z^{-2} + z^{-3}$

$\Rightarrow$ $x(n) = \{1, 2, 2, 1\}$

End of Solution

Q.38 In the circuit shown below, the value of capacitor C required for maximum power to be transferred to the load is



(a) 1 nF

(b) 1 μF

(c) 1 mF

(d) 10 mF

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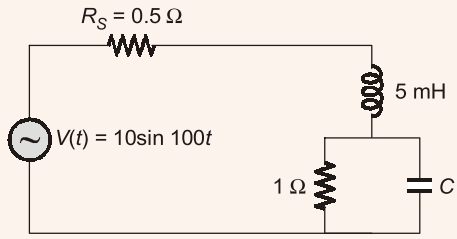
Ans. (d)



The frequency at which the load is resistive and it is equal to 0.5 Ω i.e. The load is resistive means, the imaginary put of the load is equal to zero and real part is equal to 0.5 Ω.

$$Z_{load} = \frac{1\times\frac{1}{Cs}}{1+\frac{1}{Cs}} + Ls = \frac{1}{1+Cs} + Ls$$

$$= \frac{(1-Cs)}{1-C^2s^2} + Ls$$

Real part of the $Z_{load} = \dfrac{1}{1+Cs^2}$

Put $s = j\omega$; $Z_{load} = \dfrac{1}{1+\omega^2C^2} = 0.5$

Putting, $\omega = 100$ r/s

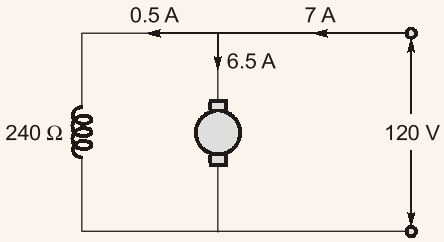
we get, $C = 10$ mF

End of Solution

Q.39 A 120 V DC shunt motor takes 2 A at no load. It takes 7 A on full load while running at 1200 rpm. The armature resistance is 0.8 Ω, and the shunt field resistance is 240 Ω. The no load speed, in rpm, is_____.

Ans. (1241.81)

Shunt motor take 7 A on full load and runs @ 1200 rpm.



$\therefore$ $E_{b1} = 120 - 65(0.8)$

$E_{b1} = 114.8$ V

$N_1 = 1200$ rpm

Shunt motor takes 2 A @ no load

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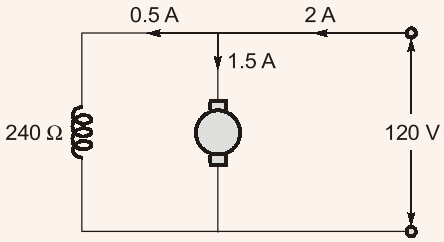


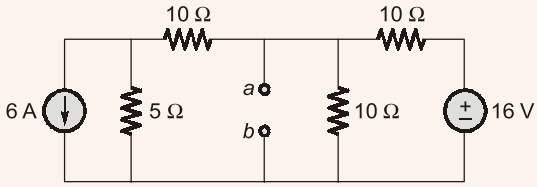
$E_{b2} = 120 - 1.5(0.8) = 118.8$

For shunt motor, $\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}}$

$\therefore \quad N_2 = \frac{118.8}{114.8} \times 1200 = 1241.81 \text{rpm}$

End of Solution

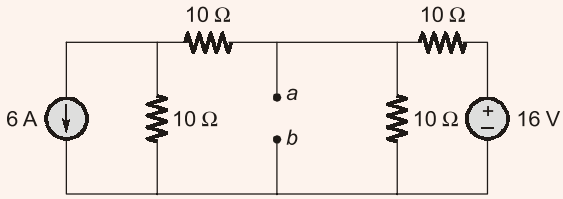
Q.40 For the network given in figure below, the Thevenin's voltage V_{ab} is



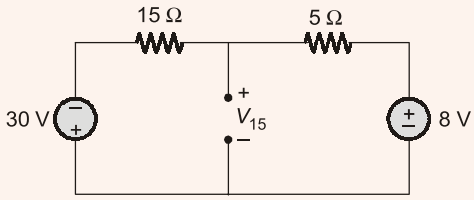
(a) –1.5 V (b) –0.5 V
(c) 0.5 V (d) 1.5 V

Ans. (a)

Consider the following circuit,



After rearragement we get,



From circuit using KCL,

Voltage, $\frac{V_{15} + 30}{15} + \frac{V_{15} - 8}{5} = 0$

$V_{15} + 30 + 3V_{15} - 24 = 0$

$V_{15} = -1.5 \text{ V}$

End of Solution

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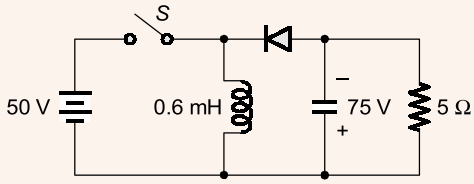
Q.41 In the circuit shown all elements are ideal and the switch S is operated at 10 kHz and 60% duty ratio. The capacitor is large enough so that the ripple across it is negligible and at steady state acquires a voltage as shown. The peak current in amperes drawn from the 50 V DC source is _____. (Give the answer up to one decimal place.)



Ans. (40)

Buckboost converter

$$V_0 = \frac{\alpha V_S}{1-\alpha}$$

$$V_S = 50 \text{ V}$$

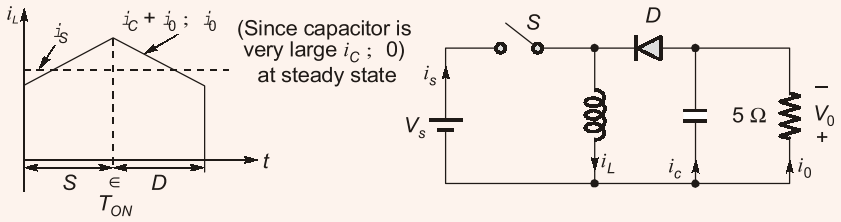
$$\alpha = 0.6$$

$$V_0 = 75 \text{ V}$$

$$\frac{V_0}{V_S} = \frac{I_S}{I_0} = \frac{\alpha}{1-\alpha} = \frac{0.6}{1-0.6} = \frac{0.6}{0.4} = \frac{3}{2}$$

$$I_0 = \frac{V_0}{R} = \frac{75}{5} = 15 \text{ A}$$

$$I_S = \frac{\alpha}{1-\alpha} \cdot I_0 = \frac{3}{2} \times 15 = 22.5 \text{ A}$$



Since capacitor is very large $i_C = 0$ at steady state

$$(i_L)_{avg} = (i_S)_{avg} + (i_0)_{avg}$$

$$I_L = I_S + I_0$$

$$I_L = 22.5 + 15 = 37.5 \text{ A}$$

$\therefore$ $$I_L = 37.5 \text{ A}$$

$$\Delta I_L = \frac{\alpha V_S}{fL} = \frac{0.6 \times 50}{10 \times 10^3 \times (0.6 \times 10^{-3})} = 5 \text{ A}$$

$$(i_L)_{peak} = I_L + \frac{\Delta I_L}{2} = 37.5 + \frac{5}{2} = 40 \text{ A}$$

$\therefore$ Peak value of current drawn from source

$$= (i_L)_{peak} = 40 \text{ A}$$

End of Solution

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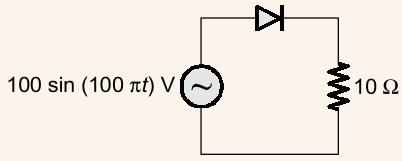
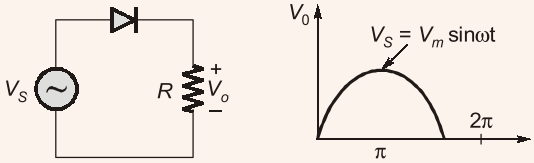
Q.42 In the circuit shown in the figure, the diode used is ideal. The input power factor is _____. (Give the answer up to two decimal places.)



Ans. (0.707)



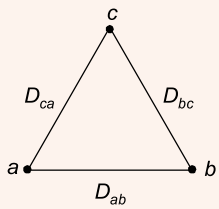
$$V_{or} = \frac{V_m}{2}$$

$$PF = \frac{V_{or}}{V_{sr}} = \frac{V_m / 2}{V_m / \sqrt{2}} = \frac{1}{\sqrt{2}} = 0.707$$

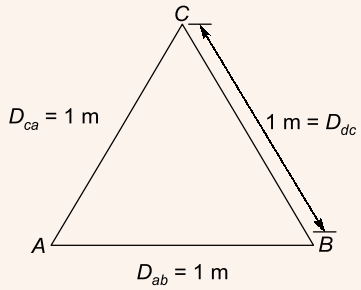
$$PF = 0.707$$

End of Solution

Q.43 Consider an overhead transmission line with 3-phase. 50 Hz balanced system with conductors located at the vertices of an equilateral triangle of length $D_{ab} = D_{bc} = D_{ca} = 1$ m as shown in figure below. The resistances of the conductors are neglected. The geometric mean radius (GMR) of each conductor is 0.01 m. Neglecting the effect of ground, the magnitude of positive sequence reactance in Ω/km (rounded off to three decimal places) is _____ .



Ans. (0.289)



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$$X_L = 2\pi fL$$

$$= 2\pi f \times 2 \times 10^{-7} \ln\left(\frac{D_m}{D_s}\right)$$

$$= 2\pi \times 50 \times 2 \times 10^{-7} In\left(\frac{1}{0.01}\right)$$

$$= 2.89 \times 10^{-4}\ \Omega/\text{m}$$

$$X_L = 0.289\ \Omega/\text{km}$$

End of Solution

Q.44 The root locus of the feedback control system having the characteristic equation $s^2 + 6Ks + 2s + 5 = 0$ where $K > 0$, enters into the real axis at

(a) $s = -1$ (b) $s = -\sqrt{5}$

(c) $s = -5$ (d) $s = \sqrt{5}$

Ans. (b)

$$GH(s) = \frac{6Ks}{s^2 + 2s + 5}$$

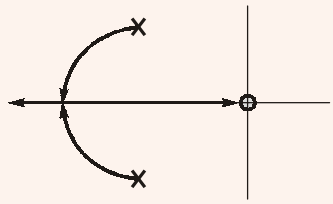
The point at which root locus enters real axis (breakaway point) is given by

$$\frac{dK}{ds} = 0$$

$$K = -\frac{(s^2 + 2s + 5)}{6s}$$

$$\frac{dK}{ds} = 0 \Rightarrow s = \pm\sqrt{5}$$

$\therefore$ $s = -\sqrt{5}$



End of Solution

Q.45 The eigenvalues of the matrix given below are

$$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -3 & -4 \end{bmatrix}$$

(a) (0, –1, –3) (b) (0, –2, –3)

(c) (0, 2, 3) (d) (0, 1, 3)

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Ans. (a)

The characteristics equation is $|A - \lambda I| = 0$

$$\begin{vmatrix} 0-\lambda & 1 & 0 \\ 0 & 0-\lambda & 1 \\ 0 & -3 & -4-\lambda \end{vmatrix} = 0$$

$$-\lambda(4\lambda + \lambda^2 + 3) - 1(0 - 0) = 0$$

$$-\lambda(\lambda^2 + 4\lambda + 3) = 0$$

$$\lambda = 0, (\lambda + 1)(\lambda + 3) = 0$$

$$\lambda = -1, -3$$

$$\lambda = (0, -1, -3)$$

End of Solution

Q.46 A person decides to toss a fair coin repeatedly until he gets a head. He will make at most 3 tosses. Let the random variable Y denote the number of heads. The value of var{Y}, where var{·} denotes the variance, equals

(a) $\frac{7}{8}$ (b) $\frac{49}{64}$

(c) $\frac{7}{64}$ (d) $\frac{105}{64}$

Ans. (c)

y : No. of Heads	0	1
$P(y)$	1/8	7/8

$$E(y) = 0 \times \frac{1}{8} + 1 \times \frac{7}{8} = \frac{7}{8}$$

$$E(y^2) = 0^2\left(\frac{1}{8}\right) + 1^2 \times \frac{7}{8} = \frac{7}{8}$$

$$\text{Variance}\,(y) = E(y^2) - (E(y))^2$$

$$= \frac{7}{8} - \frac{49}{64} = \frac{56 - 49}{64} = \frac{7}{64}$$

End of Solution

Q.47 A star-connected, 12.5 kW, 208 V (line), 3-phase, 60 Hz squirrel cage induction motor has following equivalent circuit parameters per phase referred to the stator: $R_1 = 0.3\ \Omega$, $R_2 = 0.3\ \Omega$, $X_1 = 0.41\ \Omega$, $X_2 = 0.41\ \Omega$. Neglect shunt branch in the equivalent circuit. The starting current (in Ampere) for this motor when connected to an 80 V (line), 20 Hz, 3-phase AC source is _____.

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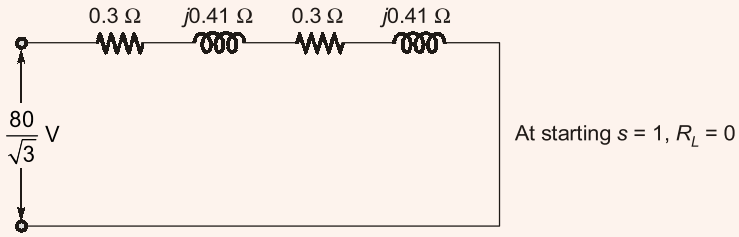
Ans. (70.05)

Equivalent circuit representation during starting – according to question.



Total resistance reference to stator = 0.6 Ω

Total reactance reference to stator = 0.82 Ω

Reactance for 60 Hz → 0.82 Ω

Reactance for 20 Hz → ?

$\because \quad X_e \propto F \quad$ Reactance for 20 Hz $\Rightarrow \frac{20}{60} \times 0.82$

$\therefore$ X for 20 Hz frequency = 0.273 Ω

$$\therefore \text{ Starting current } \Rightarrow I_{st} = \frac{80\sqrt{3}}{\sqrt{(0.6)^2 + (0.273)^2}} = 70.05\,\text{A}$$

End of Solution

Q.48 A 220 V, 10 kW, 900 rpm separately excited DC motor has an armature resistance R_a = 0.02 Ω. When the motor operates at rated speed and with rated terminal voltage, the electromagnetic torque developed by the motor is 70 Nm. Neglecting the rotational losses of the machine, the current drawn by the motor from the 220 V supply is

(a) 34.2 A (b) 30 A

(c) 22 A (d) 4.84 A

Ans. (30)

Neglecting rotor loss,

$$E_b I_a = 10 \text{ kW}$$
$$(V - I_a R_a)\, I_a = 10 \text{ kW}$$
$$[220 - I_a(0.02)]\, I_a = 10000$$
$$220 I_a - 0.02 I_a^2 - 10000 = 0$$
$$0.02 I_a^2 - 220 I_a + 10000 = 0$$

By solving, $I_a = 45.75$ A

Torque corresponding,

$$T = \frac{60}{2\pi N} E_b I_a$$

$$\therefore \quad T = \frac{60}{2\pi(900)} 10000 = 106.15 \text{ N-m}$$

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Separately excited motor,

$\therefore \quad T \propto I_a$

For a torque 106.15 N-m,

$I_a = 45.75$ A

For a torque 70 N-m,

$I_a = ?$

New, $I_a = \dfrac{70 \times 45.75}{106.15} = 30.16$ A

End of Solution

Q.49 Let $g(x) = \begin{cases} -x, & x \le 1 \\ x+1, & x \ge 1 \end{cases}$ and $f(x) = \begin{cases} 1-x, & x \le 0 \\ x^2, & x > 0 \end{cases}$.

Consider the composition of f and g i.e. (fog) $(x) = f(g(x))$. The number of discontinuities in (fog) (x) present in the interval $(-\infty, 0)$ is:

(a) 0 (b) 1

(c) 2 (d) 4

Ans. (a)

$f(x) = 1 - x; \quad x < 0$

$g(x) = -x; \quad x < 0$ (Both are continuous for $x < 0$)

$\therefore$ fog(x) is continous for $x < 0$

The composite function of two continous function is always continous.

Therefore the number of discontinuities are zero.

End of Solution

Q.50 Consider the system described by the following state space representation:

$$\begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix}$$

If $u(t)$ is a unit step input and $\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, value of output $y(t)$ at $t = 1$ sec (rounded off to three decimal places) is_____.

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Ans. (1.284)

$$y(t) = [1 \quad 0]\, x(t)$$

$$x(t) = \mathcal{L}^{-1}[(sI - A)^{-1}]\, x(0) + \mathcal{L}^{-1}[(sI - A)^{-1}]\, BU(s)]$$

$$\mathcal{L}^{-1}[(sI - A)^{-1}]\, x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$\mathcal{L}^{-1}[(sI - A)]^{-1}\, BU(s) = \begin{bmatrix} -0.25 + 0.5t + 0.25e^{-2t} \\ 0.5 - 0.5e^{-2t} \end{bmatrix}$$

$$\therefore \quad x(t) = \begin{bmatrix} 0.75 + 0.5t + 0.25e^{-2t} \\ 0.5 - 0.5e^{-2t} \end{bmatrix}$$

$$\therefore \quad y(t) = 0.75 + 0.5t + 0.25e^{-2t} = 0.75 + (0.5 \times 1) + 0.25(e^{-2})$$

$$\therefore \quad y(1) = 1.284$$

End of Solution

Q.51 A 25 kVA, 400 V, Δ-connected, 3-phase, cylindrical rotor synchronous generator requires a field current of 5 A to maintain the rated armature current under short-circuit condition. For the same field current, the open-circuit voltage is 360 V. Neglecting the armature resistance and magnetic saturation, its voltage regulation (in % with respect to terminal voltage), when the generator delivers the rated load at 0.8 pf leading, at rated terminal voltage is_____.

Ans. (–0.145)

25 kVA, 400 V, Δ-synchronous generator

$$\therefore \quad I_{\text{rated}} = \frac{25000}{\sqrt{3} \times 400} = 36.085 \text{ A}$$

$$I_{\text{phase}} = \frac{36.085}{\sqrt{3}} = 20.83 \text{ A}$$

$$X_3 = \left.\frac{V_{OC}}{I_{a_{\text{rated}}}}\right|_{I_f \text{ same}}$$

$$\therefore \quad X_s = \frac{360}{20.83} = 17.28\ \Omega/\text{phase}$$

$$E = \sqrt{(V\cos\phi + I_a R_a)^2 + (V\sin\phi - I_a X_s)^2}$$

$$= \sqrt{(400 \times 0.8)^2 + (400 \times 0.6 - 20.83(17.28))^2}$$

$$= \sqrt{(102400) + (240 - 360)^2} = 341.76 \text{ V}$$

$$\therefore \quad \%\text{V.R.} = \frac{E - V}{V} \times 100$$

$$= \frac{341.76 - 400}{400} \times 100 = -0.145\%$$

End of Solution

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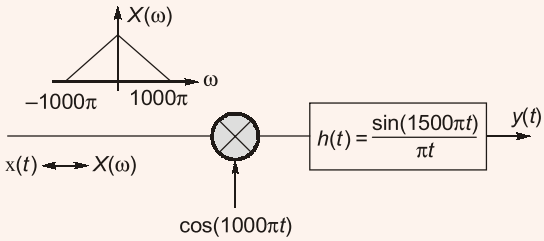
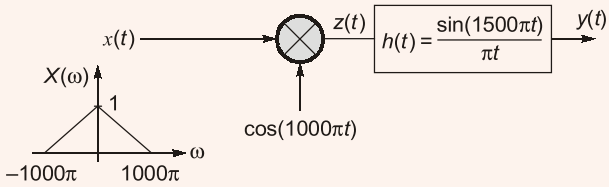
Q.52 The output $y(t)$ of the following system is to be sampled, so as to reconstruct it from its samples uniquely. The required minimum sampling rate is



(a) 1000 samples/s
(b) 1500 samples/s
(c) 2000 samples/s
(d) 3000 samples/s

Ans. (b)

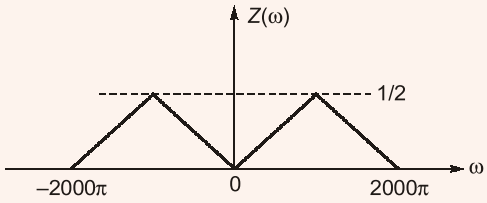


From the above block digaram,

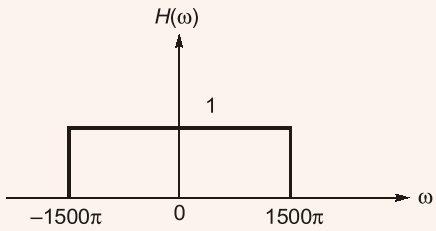
$$Z(t) = x(t)\cos 1000\pi t$$

By using modulation property of fourier transform,

$$Z(\omega) = \frac{1}{2}[X(\omega + 1000\pi) + X(\omega - 1000\pi)]$$



Now, $h(t) = \dfrac{\sin 1500\pi t}{\pi t} = 1500\,sa(1500\pi t)$



Thus, $H(\omega)$ is a low pass filter and it will pass frequency, component of $Z(\omega)$ upto 1500π rad/sec.

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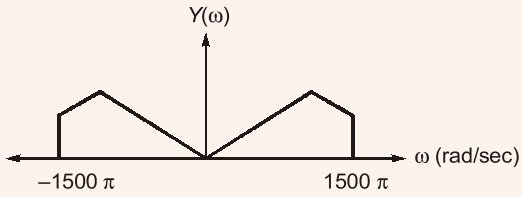
Thus,



Therefore, maximum frequency component of $y(t)$ is

$$\omega_m = 1500\pi \text{ rad/sec}$$

or $$f_m = 750 \text{ Hz}$$

So, the minimum sampling rate for $y(t)$ is

$$f_{s\,\min} = 2\,f_m = 2 \times 750 = 1500 \text{ Hz}$$
$$= 1500 \text{ samples/sec}$$

End of Solution

Q.53 The range of K for which all the roots of the equation $s^3 + 3s^2 + 2s + K = 0$ are in the left half of the complex s-plane is

(a) $0 < K < 6$ (b) $0 < K < 16$

(c) $6 < K < 36$ (d) $6 < K < 16$

Ans. (a)

From the given equation,

$$s^3 + 3s^2 + 2s + K = 0$$

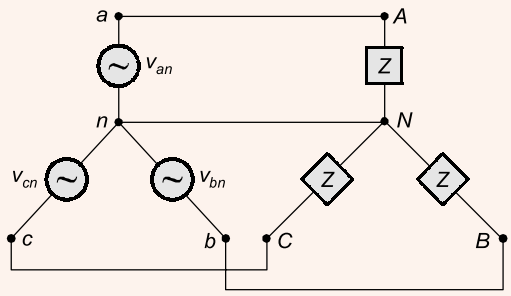
Using Routh's criterion, we get

$$K < 6 \text{ and } K > 0$$

or $$0 < K < 6$$

End of Solution

Q.54 For the balanced Y-Y connected 3-phase circuit shown in the figure below, the line-line voltage is 208 V rms and the total power absorbed by the load is 432 W at a power factor of 0.6 leading.



The approximate value of the impedance Z is

(a) $33\angle -53.1^\circ\,\Omega$ (b) $60\angle 53.1^\circ\,\Omega$

(c) $60\angle -53.1^\circ\,\Omega$ (d) $180\angle -53.1^\circ\,\Omega$

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Ans. (c)

For star connection,

$$P_{3\text{-}\phi} = \left|\frac{V_L^2}{Z}\right|.\cos\phi$$

$$|Z| = \frac{V_L^2}{P_{3\text{-}\phi}}.\cos\phi = 60\,\Omega = \frac{208^2}{430}\times 0.6$$

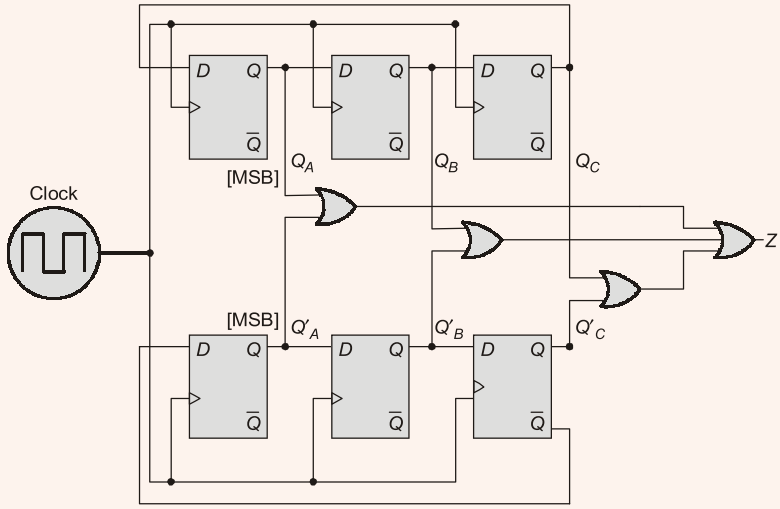
$$\cos\phi = 0.6 \text{ lead}$$

$$\phi = 53.13^\circ$$

$$\therefore \quad Z = 60\angle -53.13^\circ\Omega$$

End of Solution

Q.55 For the synchronous sequential circuit shown below, the output Z is zero for the initial conditions $Q_AQ_BQ_C = Q_A'Q_B'Q_C' = 100$.



The minimum number of clock cycles after which the output z would again become zero is _____.

Ans. (6)

Clock	Q_A	Q_B	Q_C	Q'_A	Q'_B	Q'_C	$Q_A \oplus Q'_A$	$Q_B \oplus Q'_B$	$Q_C \oplus Q'_C$	Z
0	1	0	0	1	0	0	0	0	0	0
1	0	1	0	1	1	0	1	0	0	1
2	0	0	1	1	1	1	1	1	0	1
3	1	0	0	0	1	1	1	1	1	1
4	0	1	0	0	0	1	0	1	1	1
5	0	0	1	0	0	0	0	0	1	1
6	1	0	0	1	0	0	0	0	0	0

The output Z will again become zero after 6 clock cycles.

End of Solution

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GENERAL ABILITY

Q.1 There are 3 red socks, 4 green socks and 3 blue socks. You choose 2 socks. The probability that they are of the same colour is

(a) 1/5 (b) 7/30
(c) 1/4 (d) 4/15

Ans. (d)

End of Solution

Q.2 Choose the option with words that are not synonyms.

(a) aversion, dislike (b) luminous, radiant
(c) plunder, loot (d) yielding, resistant

Ans. (d)

End of Solution

Q.3 There are five buildings called V, W. X, Y and Z in a row (not necessarily in that order). V is to the West of W. Z is to the East of X and the West of V. W is to the West of Y. Which is the building in the middle?

(a) V (b) W
(c) X (d) Y

Ans. (a)

End of Solution

Q.4 Saturn is _____ to be seen on a clear night with the naked eye.

(a) enough bright (b) bright enough
(c) as enough bright (d) bright as enough

Ans. (b)

Enough is an adverb. It is usually positioned after the adjective/adverb it modifies.

End of Solution

Q.5 A test has twenty questions worth 100 marks in total. There are two types of questions. Multiple choice questions are worth 3 marks each and essay questions are worth 11 marks each. How many multiple choice questions does the exam have?

(a) 12 (b) 15
(c) 18 (d) 19

Ans. (b)

End of Solution

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Q.6 The number of roots of $e^x + 0.5x^2 - 2 = 0$ in the range [–5, 5] is

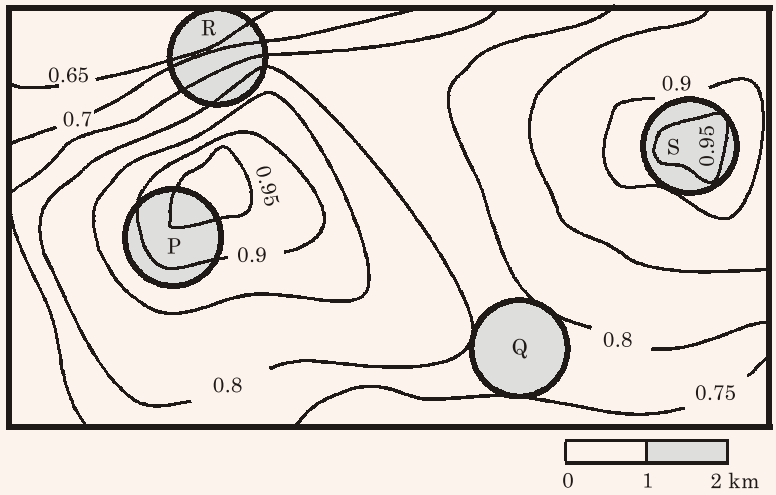
(a) 0 (b) 1

(c) 2 (d) 3

Ans. (c)

End of Solution

Q.7 An air pressure contour line joins locations in a region having the same atmospheric pressure. The following is an air pressure contour plot of a geographical region. Contour lines are shown at 0.05 bar intervals in this plot.



If the possibility of a thunderstorm is given by how fast air pressure rises or drops over a region, which of the following regions is most likely to have a thunderstorm?

(a) *P* (b) Q

(c) *R* (d) *S*

Ans. (c)

End of Solution

Q.8 "We lived in a culture that denied any merit to literary works, considering them important only when they were handmaidens to something seemingly more urgent-namely ideology. This was a country where all gestures, even the most private, were interpreted in political terms,".

The author's belief that ideology is not as important as literature is revealed by the word:

(a) 'culture' (b) 'seemingly'

(c) 'urgent' (d) 'political'

Ans. (c)

End of Solution

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Q.9 X is a 30 digit number starting with the digit 4 followed by the digit 7. Then the number X^3 will have

(a) 90 digits
(b) 91 digits
(c) 92 digits
(d) 93 digits

Ans. (a)

End of Solution

Q.10 There are three boxes. One contains apples, another contains oranges and the last one contains both apples and oranges. All three are known to be incorrectly labelled. If you are permitted to open just one box and then pull out and inspect only one fruit, which box would you open to determine the contents of all three boxes?

(a) The box labelled 'Apples'
(b) The box labelled 'Apples and Oranges'
(c) The box labelled 'Oranges'
(d) Cannot be determined

Ans. (b)

End of Solution

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